Tributyl-(trimethylsilylmethyl)-tin: Synthesis of 2-Oxoalkylsilanes (Silylmethyl Ketones) via *Transmetallation**

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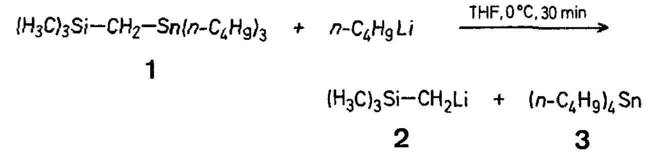
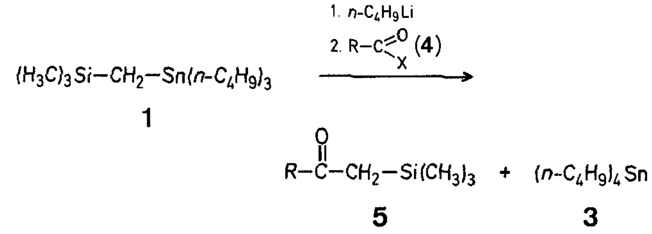
2-Oxoalkylsilanes (silylmethyl ketones, β-ketosilanes, **5**) are a versatile class of silylated synthons capable of undergoing a variety of useful synthetic transformations. Although not normally accessible by direct silylation of ketones, numerous indirect methods from carboxylic acids[1], acid chlorides[2], esters[3], anhydrides[4], and other, non-carboxylic acid derived sources[5] exist for their preparation. Of these, delivery of silicon to substrate in the form of trimethylsilylmethyllithium (**2**) has been achieved for esters of aliphatic carboxylic acids[3] and benzoic acid[1]; however, the rather tedious preparation of this reagent from chloromethyltrimethylsilane via lithium-halogen exchange[6] or from tetramethylsilane via direct lithiation[7] often precludes its routine utilization.

We recently demonstrated that the transmetallation reaction between tributyl-(trimethylsilylmethyl)-tin (**1**) and butyllithium in tetrahydrofuran/hexane at 0 °C proceeds in quantitative yield within 30 minutes.



$$\underset{\mathbf{1}}{(H_3C)_3Si{-}CH_2{-}Sn(n\text{-}C_4H_9)_3} + n\text{-}C_4H_9Li \xrightarrow{\text{THF, 0°C, 30 min}} \underset{\mathbf{2}}{(H_3C)_3Si{-}CH_2Li} + \underset{\mathbf{3}}{(n\text{-}C_4H_9)_4Sn}$$

Application of this *in situ* technique for the generation of trimethylsilylmethyllithium (**2**) to the methylenation of aldehydes and ketones (Peterson olefination) gave the desired alkenes in yields comparable to or greater than reported procedures[8]. We have now utilized the above transmetallation for the synthesis of 2-oxoalkylsilanes (**5**) from carboxylic acids, esters, and chlorides (**4**).



$$\underset{\mathbf{1}}{(H_3C)_3Si{-}CH_2{-}Sn(n\text{-}C_4H_9)_3} \xrightarrow{\text{1. } n\text{-}C_4H_9Li \quad \text{2. } R{-}C(=O){-}X\ (\mathbf{4})} \underset{\mathbf{5}}{R{-}\overset{\displaystyle O}{\overset{\|}{C}}{-}CH_2{-}Si(CH_3)_3} + \underset{\mathbf{3}}{(n\text{-}C_4H_9)_4Sn}$$

In agreement with earlier reports[3], substitution at C-1 of alkanoic esters is critical; maximum yield of **5** is obtained from the secondary ester methyl cyclohexanecarboxylate (**4**, $R = c\text{-}C_6H_{11}$, $X = OCH_3$) rather than the primary esters methyl octanoate (**4**, $R = n\text{-}C_7H_{15}$, $X = OCH_3$) or methyl hexanoate (**4**, $R = n\text{-}C_5H_{11}$, $X = OCH_3$). This divergence in reactivity is also observed in the corresponding acid chlorides (**4**, $R = n\text{-}C_7H_{15}$ or $n\text{-}C_5H_{11}$, $X = Cl$). The secondary carboxylic acid **4**, $R = c\text{-}C_6H_{11}$, $X = OH$, however, gave none of the desired β-ketosilane **5a** while (the primary) octanoic carboxylic acid (**4**, $R = n\text{-}C_7H_{15}$, $X = OH$) afforded β-ketosilane **5b** only in modest quantity. In contrast to the aliphatic series, the optimum yield of ω-trimethylsilylacetophenone (**5d**) was realized from benzoic acid rather than methyl benzoate or benzoyl chloride.

Isolation of the β-ketosilanes **5** is routinely accomplished by filtration of the crude reaction mixture over florisil® with hexane as eluent to remove tetrabutyltin (**3**) followed by elution of the product with ether and distillation. In the case of ω-trimethylsilylacetophenone (**5d**), prolonged contact with florisil® resulted in conversion to acetophenone; however, this transformation may be minimized (~5%) by rapid filtration. No hydrodesilylation was noted for the aliphatic β-ketosilanes under these conditions. Additionally, no compounds resulting from carbonyl addition by butyllithium have been observed.

The significant improvement in yield attended by this *in situ* procedure, the ready availability of **1** and its facile conversion to reagent **2** argue well for the routine application of this method in organic synthesis.

Tributyl-(trimethylsilylmethyl)-tin (1):

A flame-dried 2000 ml flask equipped with addition funnel, nitrogen inlet, and septum-capped neck is charged with dry tetrahydrofuran (450 ml) and diisopropylamine (40.0 ml, 0.285 mol) under nitrogen. The flask and contents are cooled to 0 °C and a 1.5 molar solution (167 ml, 0.25 mol) of butyllithium in hexane is added dropwise with stirring. After 15 min, tributylstannane (66 ml, 0.25 mol) is added dropwise, the resultant light green solution is stirred at 0 °C for an additional 30 min, and chloromethyltrimethylsilane (34.9 ml, 0.25 mol) is added dropwise. After 30 min at 0 °C, water (300 ml) and hexane (100 ml) are added and the layers are separated. The organic layer is

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Table. Trimethylsilylmethyl Ketones (2-Oxoalkylsilanes, **5**) from Carboxylic Acid Derivatives **(4)** and Trimethylsilylmethyllithium **(2)**

R	X	Equivalents of **1**	Temperature [°C], Time	**5**	Yield[a] [%]	b.p. (bath) [°C]/torr	Lit. Data or Molecular formula
c-C_6H_{11}	OCH_3	2.0	−78°, 5 min	**a**	82	95°/0.5	120°/0.5[3]
	Cl	2.4	−78°, 10 min	**a**	88		
	OH	2.4	−78° to 25°, 12 h		—		
n-C_7H_{15}	OCH_3	2.0	−78°, 30 min	**b**	68	85°/0.5	$C_{12}H_{26}OSi$ (214.4)[c]
	Cl	2.0	−78°, 30 min	**b**	32		
	OH	2.0	0–25°, 2 h	**b**	44[b]		
n-C_5H_{11}	OCH_3	2.1	−78°, 30 min	**c**	44	85°/2.0	$C_{10}H_{22}OSi$ (186.4)[d]
C_6H_5	OCH_3	2.0	−78°, 15 min	**d**	55	85°/0.3	104°/3.1[11]
	Cl	2.0	−78°, 30 min	**d**	30		
	OH	2.0	0–25°, 1 h	**d**	71		

[a] Yield of isolated product.
[b] Yield based on recovered starting material.

[c] calc.	C 67.22	H 12.22	[d] calc.	C 64.45	H 11.90
found	67.21	12.30	found	64.44	12.07

washed with water (3 × 100 ml), dried with sodium sulfate, and concentrated under reduced pressure to afford a light green oil. The crude product is filtered through silica gel (200 g) using hexane as eluent and distilled in vacuo to give **1** as a colorless liquid; yield: 87 g (92%); b.p. 146 °C/2.5 torr.

$C_{16}H_{38}SiSn$	calc.	C 50.94	H 10.15
(377.2)	found	51.06	10.24

I.R. (film): ν = 1475, 1270, 1260, 1010, 870, 840, 765, 730, 695 cm^{-1}.

^{1}H-N.M.R. (60 MHz, $CDCl_3$): δ = 1.7–0.6 (m, 27 H); 0.0 (s, 9 H); −0.3 ppm (s, 2 H).

Cyclohexyl Trimethylsilylmethyl Ketone (5a); Typical Procedure:
To a flame-dried flask with septum-capped side arm under nitrogen is added a solution of tributyl-(trimethylsilylmethyl)-tin (**1**; 2.263 g, 6.00 mmol) in dry tetrahydrofuran (8 ml). The flask and contents are cooled to 0 °C and a 1.5 molar solution (4 ml, 6 mmol) of butyllithium in hexane is added dropwise with stirring. After 30 min, the solution of trimethylsilylmethyllithium **(2)** thus obtained is added dropwise via cannula to a solution of cyclohexanecarbonyl chloride (**4**, R = c-C_6H_{11}, X = Cl; 0.33 ml, 2.50 mmol) in dry tetrahydrofuran (6.0 ml) maintained at −78 °C. The mixture is stirred at −78 °C for 10 min; then, aqueous 10% ammonium chloride (50 ml) is added and the mixture is extracted with hexane (3 × 20 ml). The organic extracts are washed with water (3 × 20 ml), dried with sodium sulfate, and concentrated under reduced pressure. The crude product is rapidly filtered through florisil® (15 g) using hexane (100 ml) as solvent to remove tin-containing by-products and is eluted with ether (50 ml). Kugelrohr distillation affords **5a** as colorless oil; yield: 431 mg (88%); b.p. 95 °C (oven temperature)/0.5 torr. [The spectral data of **5a** thus obtained were in accord with the literature data[3]].

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[1] R. A. Ruden, B. L. Gaffney, *Synth. Commun.* **5**, 15 (1975).

[2] T. H. Chan, E. Chang, E. Vinokur, *Tetrahedron Lett.* **1970**, 1137.

[3] M. Demuth, *Helv. Chim. Acta* **61**, 3136 (1978).

[4] C. R. Hauser, C. R. Hance, *J. Am. Chem. Soc.* **74**, 5091 (1952).

[5] See, for example:
P. F. Hudrlik, D. J. Peterson, *J. Am. Chem. Soc.* **97**, 1464 (1975).
P. F. Hudrlik et al., *Tetrahedron Lett.* **1976**, 1453.
M. Obayashi, K. Utimoto, H. Nozaki, *Tetrahedron Lett.* **1977**, 1807; **1978**, 1383; *Bull. Chem. Soc. Jpn.* **52**, 2646 (1979).
T. Sato, T. Abe, I. Kuwajima, *Tetrahedron Lett.* **1978**, 259.

[6] J. W. Connolly, G. Urry, *Inorg. Chem.* **2**, 645 (1963).

[7] D. J. Peterson, *J. Organomet. Chem.* **9**, 373 (1967).

[8] D. E. Seitz, A. Zapata, *Tetrahedron Lett.* **1980**, 3451.

[9] A. G. Brook, W. W. Limburg, D. M. McRae, S. A. Fieldhouse, *J. Am. Chem. Soc.* **89**, 704 (1967).

0039-7881/81/0732-0558 $ 03.00